PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04Q 7/38, H04J 3/06, G01S 5/06, H04B 7/26

A1

(11) International Publication Number: WO 98/52376

(43) International Publication Date: 19 November 1998 (19.11.98)

(21) International Application Number: PCT/EP97/02400

(22) International Filing Date: 9 May 1997 (09.05.97)

(71) Applicant *(for all designated States except US)*: NOKIA TELECOMMUNICATIONS OY [FI/FI]; P.O. Box 300, FIN–00045 Nokia Group (FI).

(72) Inventors; and

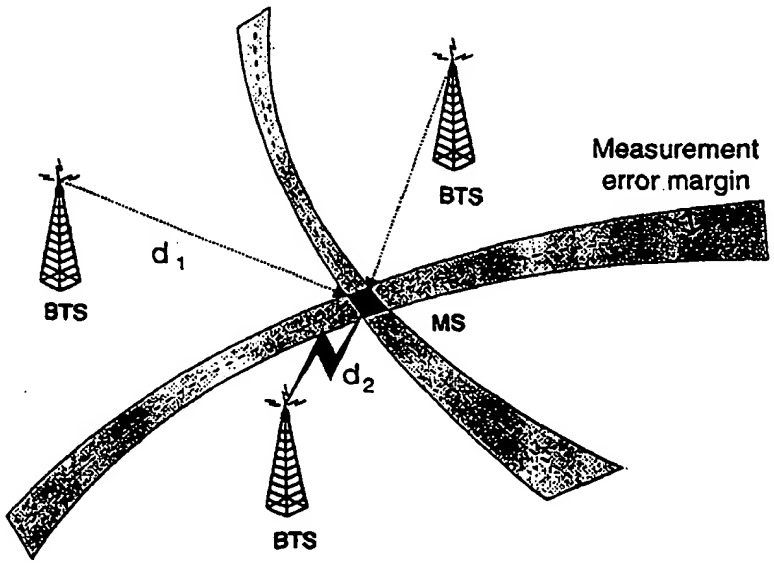
(75) Inventors/Applicants *(for US only)*: SILVENTOINEN, Marko [FI/FI]; PSR 9 D, FIN–00053 Helsinki (FI). RANTALAINEN, Timo [FI/FI]; Meripuistotie 4 A 7, FIN–00200 Helsinki (FI).

(74) Agent: PELLMANN, Hans–Bernd; Tiedtke–Bühling–Kinne et al, Bavariaring 4, D–80336 München (DE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: A METHOD FOR DETERMINING TIMING DIFFERENCES BETWEEN RADIO TRANSMITTERS AND A RADIO NETWORK INCORPORATING THE SAME



(57) Abstract

There are proposed a method for determining timing differences between a plurality of radio transmitters (BTS) and a radio network incorporating the method. Timing information of signals received by measuring means from said plurality of radio transmitters (BTS) is determined. The timing differences between said plurality of radio transmitters (BTS) are determined on the basis of said timing information determined by said measuring means and the respective distance differences between said plurality of radio transmitters (BTS) and said measuring means. This method can be advantageously applied to locating mobile stations in a mobile radio network.

BNSDOCID: <WO___9852376A1_I_>

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

BNSDOCID: <WO___9852376A1_I_>

A METHOD FOR DETERMINING TIMING DIFFERENCES BETWEEN RADIO TRANSMITTERS AND A RADIO NETWORK INCORPORATING THE SAME

FIELD OF THE INVENTION

The present invention relates to a method for determining timing differences between radio transmitters and a radio network incorporating the same. More specifically, the present invention relates to the determination of timing differences between base transceiver stations in a mobile radio network. This method of determining the real time differences is based on the measurement of the observed time differences.

BACKGROUND OF THE INVENTION

In mobile radio networks such as the GSM system used throughout Europe, it is necessary that the position of each mobile station is known to the base stations with a sufficient accuracy.

There are already some methods for determining the locations of mobile stations in a mobile radio network. For many of the location methods such as those based on Time Difference on Arrival (TDOA) or Direction Finding (DF), it is necessary that the base transceiver stations operate synchronously with respect to each other. However, in the GSM mobile radio network as it is currently used in Europe, the base transceiver stations operate asynchronously with respect to each other, or the synchronisation is not accurate enough for location purposes. For this reason, it would be desirable to know the timing differences of the signals transmitted by the base transceiver stations.

BNSDOCID: <WO___9852376A1_I_>

However, no method is available at present which would be able to determine these timing differences. As a result, it is not possible to locate a particular mobile station with a high accuracy.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a method for determining timing differences between a plurality of radio transmitters in a radio network. It is another object of the present invention to provide a method for determining timing differences between a plurality of base transceiver stations in a mobile radio network which would allow to increase the accuracy of locating the mobile stations. It is a further object of the present invention to provide a radio network in which such methods can be carried out.

According to the present invention, this object is accomplished by a method for determining timing differences between a plurality of radio transmitters in a radio network, comprising the steps of determining timing information of signals received by measuring means from said plurality of radio transmitters, and determining the timing differences between said plurality of radio transmitters on the basis of said timing information determined by said measuring means and the respective distance differences between said plurality of radio transmitters and said measuring means.

According to the present invention, this object is also achieved by a radio network as defined in claim 9.

In this way, the timing differences between the plurality of radio transmitters can be determined. Thus, if the radio transmitters are base transceiver stations in a mobile radio network, it becomes possible to determine the location of any

BNSDOCID: <WO__9852376A1>

mobile station moving at some point in the mobile radio network with a much higher accuracy than has been possible in the prior art. This requires in addition that those mobile stations whose positions are to be calculated determine timing information of signals received from the plurality of base transceiver stations. Furthermore, since the knowledge of the timing differences allows to operate the base transceiver stations in a pseudo-synchronous manner, the way of effecting handovers of the mobile stations can be improved.

Advantageous embodiments of the present invention are defined in the subclaims.

The preferred embodiments of the present invention will be described in detail hereinbelow by way of example with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram illustrating the principle of determining the timing differences between two base transceiver stations in a mobile radio network according to the present invention.

Fig. 2 is a diagram showing an application example of the method according to the present invention for locating mobile stations in a mobile radio network.

Fig. 3 is a diagram showing a practical arrangement to which the method according to the present invention can be applied for locating mobile stations in a GSM system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The method according to the present invention aims at determining the timing difference of signals transmitted by

BNSDOCID: <WO___9852376A1_I_>

radio transmitters in a radio network. More specifically, the timing difference of signals transmitted by base transceiver stations in a mobile radio network can be determined. This timing difference corresponding to the synchronisation difference between the base transceiver stations is referred to as the real time difference. In theory, when the network is synchronised, two base transceiver stations should send TDMA bursts at exactly the same time, i.e. the synchronisation error between two base transceiver stations in the network should be zero. In practice, however, the mobile radio network, like GSM, is normally not synchronised, and the real time difference corresponds to the difference of the transmission times of two bursts from two base transceiver stations.

The method according to the invention is based on the calculation of the difference between the so-called observed time difference OTD and the so-called geometric time difference GTD. Namely, the observed time difference is the sum of the real time difference and the geometric time difference.

The different quantities used by the method according to the present invention will be further explained with reference to Fig. 1 which illustrates the principle of determining the timing differences between two base transceiver stations BTS1 and BTS2. As illustrated in Fig. 1, while T_1 denotes the time when a first radio signal is transmitted from the base transceiver station BTS1, this first radio signal is received by the mobile station MS at a time T_3. Accordingly, a second radio signal is transmitted by the neighboring base transceiver station BTS2 at a time T_2 and is received by the mobile station MS at a time T_4.

The observed time difference which is also referred to as the time difference on arrival (TDOA) is the time interval as

BNSDOCID: <WO__9852376A1_I_>

observed by the mobile station between the reception of two signals from two different base transceiver stations. Referring to Fig. 1, the observed time difference OTD which is continuously determined by the mobile station itself is the difference between the two reception times T_3 and T_4: OTD = $T_3 - T_4$. The real time difference RTD corresponds to the transmission time difference between the signals transmitted by the two base transceiver stations, i.e. RTD = $T_1 - T_2$. Since the transmission times T_1 and T_2 are not known to the mobile station, the real time difference is also not known to the mobile station.

Furthermore, the geometric time difference GTD represents the difference between the propagation times of the two signals transmitted by the two base transceiver stations and received by the mobile station. According to the situation illustrated in Fig. 1, GTD = $T_3 - T_1 - (T_4 - T_2)$. In other words, the geometric time difference corresponds to the respective difference of the distances d_1 and d_2 of these two different base transceiver stations from the mobile station, divided by the speed of the radio wave propagation c, i.e. GTD = $(d_1 - d_2)/c$. If the two base transceiver stations are located at the same distance from the mobile station, then GTD is zero, and the observed time difference is only due to synchronisation differences in the network. In addition, when the base transceiver stations are synchronised with each other (i.e. RTD=0), then OTD equals GTD, and the observed time difference is only due to the different positions of the base transceiver stations and the mobile station.

In addition, in order to determine the observed time difference between the signals transmitted by the base transceiver stations and to calculate the real time difference on the basis thereon, a dedicated measurement equipment is used with which some of the base transceiver stations acting as fixed measurement stations are equipped.

BNSDOCID: <WO___9852376A1_I_>

According to this embodiment of the present invention, this measurement equipment is the so-called Site Test Mobile (STM) manufactured by Nokia. As a matter of course, the present invention is by no means limited to the use of this type of measurement equipment STM, and any other type of suitable measurement equipment may also be used instead. In addition, the measurement equipment does not need to be mobile, but can be located in a fixed position. For the sake of clarity, only a single measurement equipment STM is shown in Fig. 1 at a place located somewhere between the two base transceiver stations BTS1 and BTS2.

The method according to the present invention can be advantageously applied to locating mobile stations in the area covered by the mobile radio network. Referring to Fig. 1, for calculating a location estimate of the mobile station MS in the mobile radio network, it is necessary to determine the difference between the distances d_1 and d_2 which can be obtained from the geometric time difference of the mobile station with respect to the two base transceiver stations. As a matter of course, in order to calculate the location of the mobile station, it is necessary to receive at least one further signal from a third base transceiver station which is, for the sake of clarity, not shown in Fig. 1.

More specifically, the principle underlying the application of this method to locating mobile stations will be described hereinbelow with reference to Fig. 2. The calculation of the location of the mobile station according to this method is based on the fact that the possible location of the mobile station MS between two neighbouring base transceiver stations BTS is positioned on a hyperbola since the difference between the distance d_1 of the mobile station to the first base transceiver station and the distance d_2 thereof to the second base transceiver station is constant. In other words, the mobile station concerned is subject to a constant value of

BNSDOCID: <WO___9852376A1_I_>

the observed time difference of the signals received from these two base transceiver stations. Since the measurement result has a certain error margin, the potential location area of the mobile station is in reality a band between two hyperbolae, the width of the band depending on the error margin of the measurement result. The possible location area is illustrated by a grey area in Fig. 2, while the dashed line represents the measured observed time differences. In order to actually locate the mobile station, it is necessary to receive signals from at least three base transceiver stations. In this case, the mobile station is located in the intersection of two hyperbolae obtained from two (constant) observed time differences from these three base transceiver stations (it is even possible to form a third hyperbola on the basis of the signals received from three base transceiver stations). The actual location area of the mobile station is illustrated by a black area at the intersection of the grey areas in Fig. 2. If more than three base transceiver stations and thus more observed time differences are available, the possible location area of the mobile station can be further reduced, thus increasing the accuracy of locating the mobile station.

In order to actually locate a particular mobile station on the basis of the geometric time difference, the observed time difference OTD and the real time difference RTD have to be known. Furthermore, in order to determine the real time difference, the positions of the different base transceiver stations and that of the measurement equipment STM have to be known. The positions of the base transceiver stations are predetermined and defined by co-ordinates in an x-y-plane. Since the location of the measurement equipment is also known, the geometric time differences GTD with respect to the measurement equipment can be calculated. Thus, since the observed time difference OTD between the signals received by the measurement equipment is determined by the measurement

BNSDOCID: <WO__9852376A1_I_>

equipment, it is possible to determine the real time difference RTD according to the method described above. This real time difference is calculated by determining the difference between the geometric time difference GTD corresponding to the distances of the measurement equipment to the base transceiver stations, and the observed time difference OTD.

Furthermore, since the real time difference is independent from the position at which it is determined, the calculated value corresponds to the real time difference as observed by the mobile station. Thus, after determination of the observed time difference OTD by the mobile station, the derived value is transmitted to some central unit. Thereafter, the geometric time difference can be calculated from which the distance differences between the mobile station and the base transceiver stations are determined. In this way, one hyperbola can be drawn from the signals received from two base transceiver stations, since one geometric time difference can be calculated. If signals are received from three base transceiver stations, then three hyperbolae can be drawn from two geometric time differences, thereby allowing the possible location of the mobile station to be determined.

Fig. 3 is a diagram showing a practical arrangement to which the method according to the present invention can be applied for determining the location of a mobile station in a GSM mobile radio network.

As shown by a dotted line in Fig. 3, the RTD results calculated by the measurement equipment STM are transmitted via a base station controller BSC, a mobile switching center MSC, a short message service - service center SMS-SC to a location service center LSC. Alternatively, the measurement equipment may only report the determined OTD results to the location service center which in turn calculates the real

BNSDOCID: <WO__9852376A1_I_>

time difference. The location service center can be either provided as a separate entity in the mobile radio network as shown in Fig. 3, or it can be provided in a distributed manner over the whole mobile radio network, e.g. in any of the base transceiver stations. In addition, as shown by a dashed line in Fig. 3, the TDOA information (or OTD results) can be relayed from the mobile station MS usually via the serving base transceiver station BTS, the base station controller BSC, the mobile switching center MSC, the short message service - service center SMS-SC to the location service center LSC.

In general, the location service center then calculates the difference between the OTD results transmitted from the mobile station and the RTD results transmitted from the measurement equipment STM so as to calculate a location estimate of the mobile station MS. In other words, the location service center calculates the location of the mobile station on the basis of the geometric time difference which is the difference between the observed time difference and the real time difference. The location service center then outputs the determined position co-ordinates of the mobile station to a number of applications (e.g. applications 1 and 2 shown in Fig. 3) which have issued a location request to the location service center in advance concerning a particular mobile station. Such a location request initiates the transmission of an OTD request from the location service center to the mobile station.

Since it is possible that the timing differences of the base transceiver stations vary from one measurement to the next, the OTD results calculated by the measurement equipment are periodically reported to the location service center.

As illustrated in Fig. 3, it is not necessary that every base transceiver station BTS is provided with its own measurement

BNSDOCID: <WO__9852376A1_I_>

equipment STM. For instance, in urban areas where many base transceiver stations are located close to each other, it may be sufficient to provide only e.g. every sixth base transceiver station with a measurement equipment.

Furthermore, according to another preferred embodiment of the present invention, the mobile station MS can determine its own position itself. For this purpose, the real time differences RTD calculated by either the measurement equipment or the location service center are transmitted to the mobile station. The mobile station determines the timing information of the signals received from several base transceiver stations, i.e. the observed time differences, and calculates the geometric time difference in the same manner as described above. On the basis of the geometric time difference, the mobile station is able to determine its position on its own.

More specifically, the calculated real time differences RTD or the observed time differences OTD can be transmitted from the measurement equipment STM to the location service center LSC using any of the following four channels:

- the short message service (SMS),
- undefined supplementary service data (USSD),
- a measurement report, a BSSMAP message and a message between a mobile switching center MSC and the location service center LSC, or
- a totally new message.

The short message service is a special GSM service for delivering short text messages either from one mobile station to another or from a central base station to all mobile stations in a particular geographical region. In practice, the short message service is implemented as a connectionless protocol, and the messages are transmitted on one of the

BNSDOCID: <WO___9852376A1_I_>

signalling channels (either the Slow Associated Control Channel (SACCH) or the Stand Alone Dedicated Control Channel (SDCCH)).

Furthermore, the undefined supplementary service data (USSD) are data the content of which is not defined by any specification. These data can be used by an operator to implement new operator specific services.

In addition, base station system management application part (BSSMAP) messages are used in the communication between the mobile switching center MSC and the base station system BSS. They support all procedures between the mobile switching center and the base station system which require information processing related to single calls and resource management.

According to the embodiment shown in Fig. 3, for transmission of OTD requests and results the short message service SMS is used between the base transceiver stations BTS and the mobile station MS. Furthermore, according to this embodiment, the SMS channel is also used for transmission of the RTD results in the uplink direction from the measurement equipment STM to the location service center LSC.

The use of the SACCH channel for transmission of measurement information has the following advantages. Since a SACCH burst is transmitted at intervals of 480 ms in the GSM system, the measurement information is transmitted sufficiently often. Further, the measurement information can even be transmitted during an ongoing call. Moreover, since an already existing channel is used for transmission of additional information, neither the load on the radio link is increased nor the quality of the transmitted voice signals is impaired.

The measurement process in the measurement equipment STM can be triggered and controlled by sending a special measurement

BNSDOCID: <WO___9852376A1_I_>

command signal as RTD request or command using e.g. the short message service or the undefined supplementary service data to be sent to the measurement equipment. The transmission of the command signal using the short message service is again represented by the dotted line in Fig. 3. This command signal may contain the following information:

- the number of measurement sets of one SMS message,
- the measurement frequency (e.g. once every 30 seconds),
- the measurement duration (e.g. the next ten minutes, five SMS messages or until a stop command is received), and
- the identification of those base transceiver stations BTS being measured.

Hence, according to the present invention, since the real time difference between the plurality of base transceiver stations can be accurately determined, it becomes possible to precisely determine the locations of mobile stations being positioned somewhere in the mobile radio network. In detail, experiments have shown that it is possible to reduce the mean error of mobile station location to approximately 300 m. Furthermore, the position information of a mobile station can be obtained quickly and at short intervals because the position information becomes available in real time.

Furthermore, according to the above description, the measurement equipment is located in the base transceiver station. This has the following advantages. Since the antenna for receiving the signals is located at the antenna of the base transceiver station, it has in many cases a line of sight connection to other base transceiver stations. As a result, the attenuation between signals received from neighbouring base transceiver stations is low. Furthermore, since only some software modifications in the mobile station are needed, only little additional effort is required. Thus, the present invention can be realized at almost no extra

BNSDOCID: <WO___9852376A1_I_>

cost. In addition, the measurement equipment may of course also be used for other purposes. However, it is also not necessary that the measurement equipment is located in the base transceiver station, and the measurement equipment may of course be located in some other suitable place.

In the above description, the application of the method to base transceiver stations in a mobile radio network has been described as an example. However, the method according to the present invention can as a matter of course be applied to determine the timing differences between several radio transmitters in any type of radio network.

Furthermore, although the above description referred to the Pan-European digital cellular radio network GSM as an example, the present invention can be applied with some modifications to any other digital system. For example, the present invention is also applicable to the DCS1800/1900 system or the JDC system used in Japan.

It should be understood that the above description has been made only with reference to the preferred embodiments of the present invention. Therefore, the present invention is not limited to the above described preferred embodiments, but is also intended to cover any variations and modifications to be made by a person skilled in the art within the spirit and scope of the present invention as defined in the appended claims.

BNSDOCID: <WO___9852376A1_I_>

CLAIMS

1. A method for determining timing differences between a plurality of radio transmitters (BTS), comprising the steps of:

determining timing information (OTD) of signals received by measuring means (STM) from said plurality of radio transmitters (BTS); and

determining the timing differences (RTD) between said plurality of radio transmitters (BTS) on the basis of said timing information (OTD) determined by said measuring means (STM) and the respective distance differences between said plurality of radio transmitters (BTS) and said measuring means (STM).

2. A method according to claim 1, wherein said radio transmitters are base transceiver stations (BTS) in a mobile radio network.

3. A method according to claim 2, further comprising the steps of:

determining timing information (OTD) of signals received by said mobile station (MS) from said plurality of base transceiver stations (BTS); and

determining the location of said mobile station (MS) on the basis of the timing information (OTD) determined by said mobile station (MS) and said timing differences (RTD) between said plurality of base transceiver stations (BTS).

4. A method according to claim 3, wherein said timing information (OTD) is transmitted using the short message

SDOCID: <WO___9852376A1_I_>

service (SMS), undefined supplementary service data (USSD) or a BSSMAP message.

5. A method according to claim 3 or 4, wherein said timing differences (RTD) are transmitted using the short message service (SMS), undefined supplementary service data (USSD) or a BSSMAP message.

6. A method according to any of the claims 3 to 5, wherein the step of determining said timing differences (RTD) is controlled by transmitting a command signal using the short message service (SMS) or undefined supplementary service data (USSD), wherein the command signal contains some of the following information:

the number of measurement sets of one message,
the measurement frequency,
the measurement duration, and
the identification of those base transceiver stations (BTS) being measured.

7. A method according to any of the preceding claims, wherein one or several of said plurality of radio transmitters (BTS) are provided with said measuring means (STM).

8. A method according to any of the claims 1 to 6, wherein said measuring means (STM) is/are arranged at a distance from any of said plurality of radio transmitters (BTS).

9. A radio network comprising:
a plurality of radio transmitters (BTS); and
measuring means (STM) for determining timing information (OTD) of signals received from said plurality of radio transmitters (BTS);

BNSDOCID: <WO___9852376A1_I_>

wherein the timing differences (RTD) between said plurality of radio transmitters (BTS) are determined on the basis of said timing information (OTD) determined by said measuring means (STM) and the respective distance differences between said plurality of radio transmitters (BTS) and said measuring means (STM).

10. A radio network according to claim 9, wherein one or several of said plurality of radio transmitters (BTS) are provided with said measuring means (STM).

11. A radio network according to claim 9, wherein said measuring means (STM) is/are arranged at a distance from said plurality of radio transmitters (BTS).

12. A radio network according to any of claims 9 to 11, wherein said radio network is a mobile radio network and said radio transmitters are base transceiver stations (BTS).

13. A radio network according to claim 12, wherein timing information (OTD) of signals transmitted from said plurality of base transceiver stations (BTS) is determined by a mobile station (MS); and

the location of said mobile station (MS) is determined on the basis of said timing information (OTD) determined by said mobile station (MS) and said timing differences (RTD) between said plurality of base transceiver stations (BTS).

14. A radio network according to claim 13, further comprising a location service center (LSC) for determining the location of said mobile station (MS).

15. A radio network according to claim 14, wherein said location service center (LSC) is spatially distributed over said mobile radio network.

BNSDOCID: <WO__9852376A1_I_>

16. A radio network according to claim 14 or 15, wherein said timing information (OTD) is transmitted from said measuring means (STM) to said location service center (LSC) and/or from said mobile station (MS) to said location service center (LSC) using the short message service (SMS), undefined supplementary service data (USSD) or a BSSMAP message.

17. A radio network according to any of claims 14 to 16, wherein said timing differences (RTD) are transmitted from said measuring means (STM) to said location service center (LSC) using the short message service (SMS), undefined supplementary service data (USSD) or a BSSMAP message.

18. A radio network according to any of claims 13 to 17, wherein determination of said timing differences (RTD) is controlled by transmitting a command signal using the short message service (SMS) or undefined supplementary service data (USSD), wherein the command signal contains some of the following information:

the number of measurement sets of one message,

the measurement frequency,

the measurement duration, and

the identification of those base transceiver stations (BTS) being measured.

19. A mobile station located in a mobile radio network according to any of claims 12 to 18, wherein

the timing differences (RTD) between said plurality of base transceiver stations (BTS) are transmitted to said mobile station (MS); and

said mobile station (MS) determines its position on the basis of timing information (OTD) of signals received from said plurality of base transceiver stations (BTS) and the timing differences (RTD) between said plurality of base transceiver stations (BTS).

BNSDOCID: <WO__9852376A1_I_>

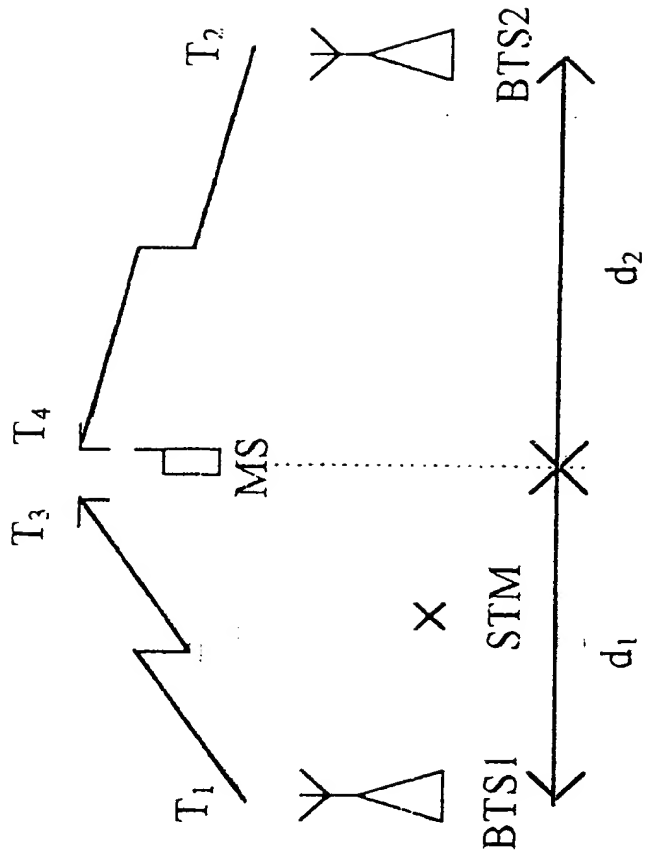


Fig. 1

BNSDOCID: <WO___9852376A1_I_>

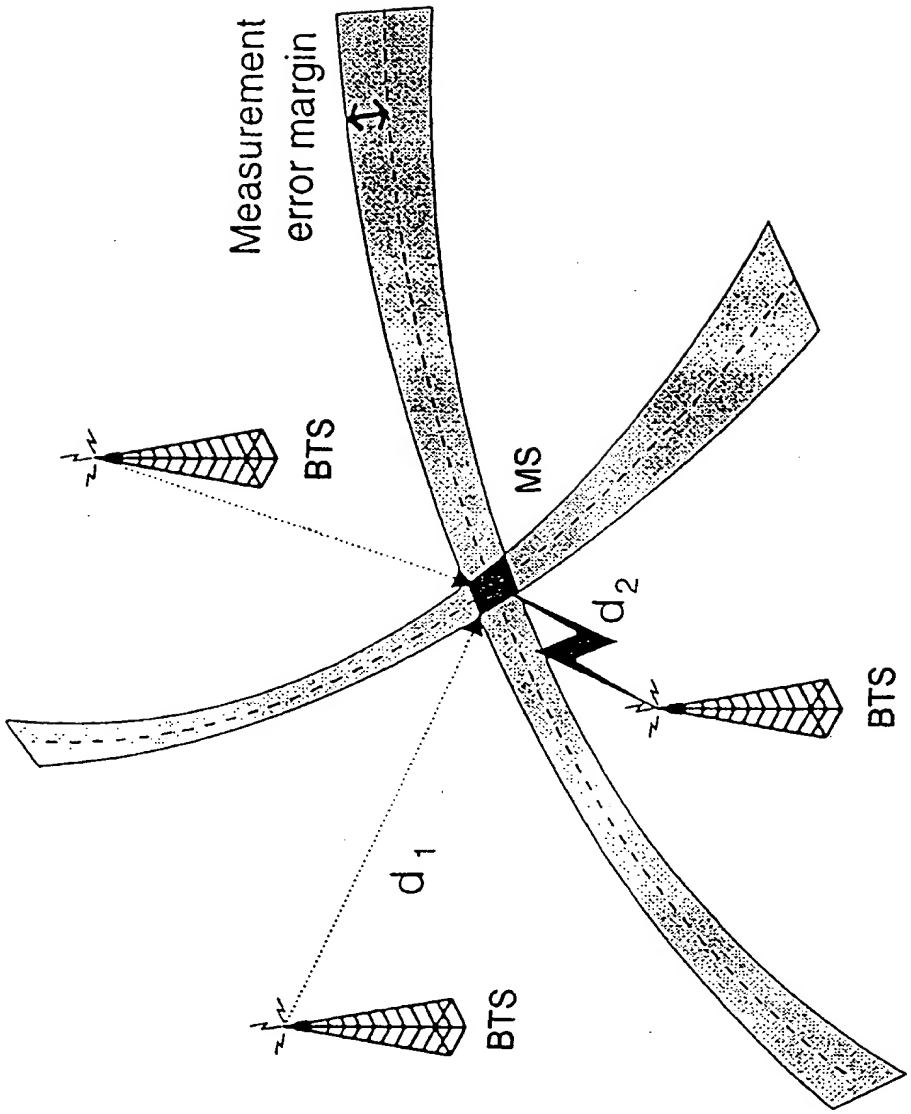


Fig. 2

BNSDOCID: <WO___9852376A1_I_>

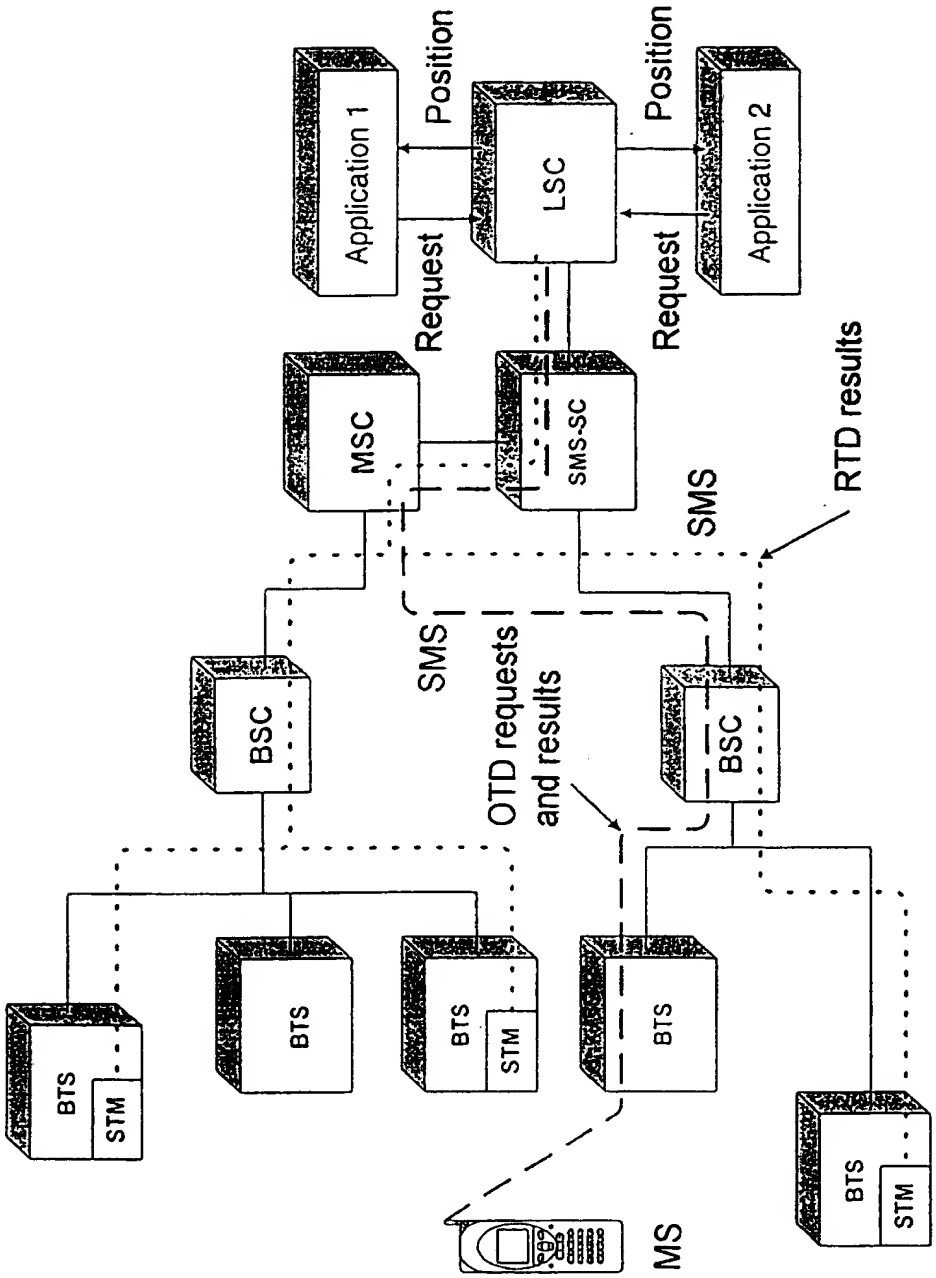


Fig. 3

BNSDOCID: <WO___9852376A1_I_>

INTERNATIONAL SEARCH REPORT

[redacted] Application No
PCT/EP 97/02400

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/38 H04J3/06 G01S5/06 H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04B H04J G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 5 128 925 A (DORNSTETTER ET AL.) 7 July 1992 see column 2, line 7 - line 20 ---	1,2,9,12 3,13,19 7,8,10
Y	EP 0 767 594 A (NOKIA MOBILE PHONES LTD) 9 April 1997 see column 4, line 29 - column 6, line 36 ---	3,13,19
A	WO 96 35306 A (TELECOM SEC CELLULAR RADIO LTD ;MUNDAY PETER ROBERT (GB); GOETZ IA) 7 November 1996 see page 7, line 26 - page 8, line 15 see page 12, line 25 - page 13, line 14 ---	1,4-6, 16,17
A	US 5 600 706 A (DUNN ET AL.) see column 8, line 60 - line 21 --- -/--	3,13,19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 January 1998	02/02/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gastaldi, G

Form PCT/ISA/210 (second sheet) (July 1992)

BNSDOCID: <WO___9852376A1_I_>

INTERNATIONAL SEARCH REPORT

ational Application No
PCT/EP 97/02400

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 512 908 A (HERRICK) 30 April 1996 see column 1, line 55 - column 2, line 60	1,9,19
A	WO 95 00821 A (OMNIPLEX INC) 5 January 1995 see page 3, line 2 - page 5, line 4	1,9,19
A	US 5 423 067 A (MANABE) 6 June 1995 see column 1, line 35 - column 3, line 35	1,9,19
E	WO 97 23785 A (UNIV SYDNEY TECH ;DRANE CHRISTOPHER R (AU); MACNAUGHTAN MALCOLM D) 3 July 1997 see page 2, line 27 - page 3, line 25	1,9,19

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

BNSDOCID: <WO___9852376A1_I_>

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 97/02400

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5128925 A	07-07-92	FR 2646302 A	26-10-90
		AT 110204 T	15-09-94
		AU 622543 B	09-04-92
		AU 5392590 A	01-11-90
		CA 2015237 A,C	26-10-90
		DE 69011579 D	22-09-94
		DE 69011579 T	19-01-95
		EP 0398773 A	22-11-90
		ES 2058837 T	01-11-94
		IE 65521 B	01-11-95
		JP 1986761 C	08-11-95
		JP 2302133 A	14-12-90
		JP 7022276 B	08-03-95
		NO 301960 B	29-12-97
EP 0767594 A	09-04-97	FI 954705 A	04-04-97
WO 9635306 A	07-11-96	AU 5507296 A	21-11-96
US 5600706 A	04-02-97	US 5295180 A	15-03-94
		FI 946147 A	30-06-95
		PL 306687 A	10-07-95
		CA 2083791 A	09-10-93
		EP 0568824 A	10-11-93
		JP 6105364 A	15-04-94
US 5512908 A	30-04-96	AU 2964595 A	09-02-96
		AU 2964695 A	09-02-96
		CA 2171325 A	25-01-96
		CA 2171333 A	25-01-96
		CN 1134752 A	30-10-96
		EP 0720749 A	10-07-96
		EP 0717852 A	26-06-96
		NZ 289719 A	24-02-97
		WO 9602006 A	25-01-96
		WO 9602007 A	25-01-96
WO 9500821 A	05-01-95	AU 7173694 A	17-01-95
US 5423067 A	06-06-95	JP 5067996 A	19-03-93

BNSDOCID: <WO___9852376A1_I_>

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 97/02400

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5423067 A		GB 2260050 A,B	31-03-93
WO 9723785 A	03-07-97	AU 1133297 A	17-07-97

BNSDOCID: <WO___9852376A1_I_>